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(54) IMPROVEMENTS RELATING TO FLUID FLOW APPARATUS

(71) We, GRISWOLD CONTROLS, a corporation organised and existing under the laws of the State of California, United States of America, of 124 East Dyer Road, Santa Ana, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fluid flow apparatus and is particularly directed to improvements in check valve construction and backflow prevention apparatus.

Check valves are commonly provided when it is desired to permit fluid flow in one direction but to prevent fluid flow in the other direction. A single check valve acting alone may leak slightly and, therefore, single check valves are not used when it is necessary to prevent any reverse flow, even in the smallest degree. In the latter situation, backflow prevention apparatus may take the form of two check valves connected in series with a "zone" between them. Both check valves remain open during normal flow in a forward direction, but in the event that downstream pressure should approach the upstream pressure within a predetermined amount, for example, two pounds per square inch, the volume of the zone between the check valves is vented to atmosphere. In such devices, downstream pressure can never exceed upstream pressure, even under vacuum conditions with the result that reverse flow is not possible.

Backflow prevention devices of the type just described have at least two serious shortcomings. The first is that in order to have a check valve which will close satisfactorily, and more significantly, in certain cases, maintain a predetermined minimum pressure, a spring force is used, and this must be overcome during normal flow in the forward direction. Unfortunately, this often results in a pressure drop of serious proportions, particularly when two check valves in series are employed. Another difficulty is that conventional apparatus for venting the zone between the check valves is usually costly, inaccurate and difficult to maintain.

According to the invention, there is provided a check valve comprising an inlet passage terminating in an annular valve seat, a barrel coaxial with the valve seat and of larger diameter than the valve seat, a valve poppet having a flange slidably guided within the barrel and being axially movable towards and away from said valve seat, a spring arranged to urge the poppet towards sealing contact with the valve seat, a chamber bounded in part by the poppet remote from the valve seat, and an outlet passage, wherein a portion of said flange projects into the outlet passage to define a region in the fluid flow path in which the velocity of flowing fluid in use is greater than in the rest of the outlet passage and the pressure is correspondingly less and wherein the chamber communiciates with said region whereby increasing flow of fluid through the check valve from the inlet passage to the outlet passage in use causes a reduction in pressure in the chamber to oppose the action of the spring.

The invention also extends to a check valve assembly comprising a check valve as defined above connected in series with another check valve as defined above, the outlet passage of one check valve forming the inlet passage of the other check valve.

The invention also provides a backflow preventer assembly comprising two check valves as defined above connected in series and defining a zone between them, and means including a control valve actuable to vent said zone to atmosphere, said control valve having means responsive to differential pressure across the upstream check valve for actuating said control valve.

Preferably, the control valve comprises a housing provided with a valve seat, a stem mounted to move axially in the housing and having a valve head movable to close against said seat, a cover, a flexible diaphragm having its periphery clamped between the cover and the housing and acting to define a chamber in the housing and a chamber in the cover, means connecting the central portion of the diaphragm to the stem, a spring in the cover chamber urging the stem in a direction to open the valve, a discharge pipe

connecting the zone to said housing, a first pressure sensing line communicating the pressure in the inlet passage of the upstream check valve to the housing chamber and a second pressure sensing line communicating the pressure in the outlet passage of the upstream check valve with the cover chamber, and a balance piston fixed on the stem slidably mounted within the housing to balance the fluid pressure force from the discharge pipe tending to move the valve head away from the valve seat.

Certain embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a sectional elevation showing a first check valve according to the invention;

Figure 2 is a sectional elevation of a second check valve according to the invention;

Figure 3 is a sectional elevation of a third check valve according to the invention;

Figure 4 is a sectional elevation of a fourth check valve according to the invention;

Figure 5 is a sectional elevation showing a double check valve assembly according to the invention, both check valves being shown in the closed position;

Figure 6 is a chart showing pressure loss plotted against flow rate in a commercial form of the double check valve assembly of Figure 5. One curve of the graph relates to a device of three-quarter inch nominal size and the other curve relates to a device of one inch nominal size;

Figure 7 is a side elevation showing a backflow preventer assembly according to the invention;

Figure 8 is an end elevation of the assembly of Figure 7.

Figure 9 is a schematic diagram in sectional elevation of the assembly of Figure 7, the parts being shown in position for full flow in the forward direction;

Figure 10 is a chart showing pressure loss plotted against flow rate for the backflow preventer assembly of Figures 7-9. One curve of the graph relates to a device of three-quarter inch nominal size and the other curve relates to the one inch nominal size;

Figure 11 is a sectional view showing a modified form of differential pressure control valve of the backflow preventer assembly, the parts being positioned for normal forward flow; and

Figure 12 is a view similar to Figure 11, the parts being shown in position corresponding to backflow conditions.

Referring to the drawings, a check valve assembly generally designated 10 is shown in various embodiments in Figures 1, 2, 3 and 4. The check valve assembly 10 includes a poppet 11 slidably mounted within a stationary barrel 12. An annular resilient ring 13 serves as a valve face and is held in place on the poppet 11 by means of a retaining washer 14 and a threaded fastening 15. A coil compression spring 17 acts on the poppet 11 to bring the resilient ring 13 into sealing engagement with a stationary annular seat 18 provided at the end of an inlet passage 19. The barrel 12 is of larger diameter than the valve seat 18.

The poppet 11 has a first flange 20 and a second flange 21 both slidably mounted within the stationary barrel 12. An annular groove 22 is defined between the flanges 20 and 21 and one or more ports 23 establish communication between the groove 22 and a spring chamber 24. Flange 20 and ring 13 define a generally annular space 29 with the seat 18. In Figure 1, the inlet terminal 26 and the outlet terminal 27 are coaxial, and the axis of movement of the poppet 11 is positioned at about 45° with respect thereto. In Figure 2, the inlet terminal *26a* and the outlet terminal *27a* are at right angles, and the axis of movement of the poppet 11 is coaxial with the inlet terminal *26a*. In Figure 3, the inlet terminal *26b* and the outlet termianl *27b* are coaxial, and the axis of movement of the poppet 11 is at right angles thereto. In Figure 4, the inlet terminal *27c* and the outlet terminal *27c* are coaxial, and the movement of the poppet 11 is along the same axis.

The check valve assembly 10 is in open position as shown in Figures 1, 2, 3 and 4. Fluid in the inlet passage 19 passes between th annular seat 18 and the resilient ring 13 into the outlet passage 28. Inlet pressure is then present in the space 29 acting upon the total pressure area of flange 20 to overcome the force of spring 17. Thus, flange 20 effectively serves as a seal between the space 29 and groove 22. In Figure 4, a stationary housing 30 encircles the barrel 12 and passageways 31 are provided to carry fluid from the space 29 to the outlet terminal *27c*.

In each case the outer diameters of the poppet flanges 20 and 21 are substantially larger than the effective diameter of the stationary seat 18, so that when the check valve is in closed position with the resilient ring 13 engaging the seat 18, the pressure in the inlet passage 19 acts over a substantially smaller area than the pressure in the spring chamber 24. When the pressure in the inlet passage 19 applied to the area of seat 18 is sufficient to overcome the force of the spring 17 and the pressure in the spring chamber 24, both the static and dynamic head are subsequently applied to the larger effective area of the flange 20. Thus, the increase in effective area when the valve first opens results in a substantial force to overcome the spring force, and the valve moves positively towards the open position.

When the check valve parts are in open position corresponding to forward flow

operation, as shown in Figures 1-4, the flow of the fluid creates a low pressure region around the poppet 11 in the groove 22. This occurs because a portion of the flange 20 and a portion of the groove 22 extend into the outlet passage 28. This reduced pressure is transmitted to the spring chamber 24 through the groove 22 and through the port or ports 23. Consequently, as the velocity of forward flow increases, the pressure in the chamber 17 acting on the effective area defined by the diameter of flange 21 decreases.

When the pressure drop across the valve falls below a predetermined value, the portion of the poppet 11 which protrudes into the outlet passage 28, Figures 1-3, and the entire poppet in Figure 4, receives the full pressure of the fluid in outlet passage 28, and the pressure thus developed acts over the full effective area of the spring chamber 24, which combined with the force of the spring 17 acts to close the valve promptly.

It will be observed that, in the construction just described, as the velocity of forward flow increases, the velocity head produces a positive opening force on the poppet 11 on the side containing the resilient ring 13 together with a lowering of pressure in the chamber 24, both effects serving to overcome the force of the spring 17. Moreover the lowering of pressure in the spring chamber is developed due to the portion of the poppet flange 20 protruding into the outlet passage 28 and creating a restriction 77 in which the momentum of fluid flow acting upon the static fluid in groove 22 results in the lowering of pressure in groove 22 and transmitted to the spring chamber through the communicating port 23. Consequently, as the demand for flow increases, the resulting momentum increase results in an ever decreasing pressure in the spring chamber. Concurrently, as the rate of flow increases, the velocity head acting upon the full effective area of flange 20 (on the side with the resilient seal) increases. With both effects thus combined, a substantial pressure differential is created across the flange 20 to create an increasing force to overcome the force of the spring. Furthermore, even with the introduction of restriction 77 and a consequent "induced" pressure drop at that point, the net result is an advantageous pressure differential across the poppet and a reduction in the total pressure drop across the valve. Moreover, the spaced flanges 20 and 21 guide the poppet in its movements within the barrel 12 with adequate clearances to avoid mechanical frictional losses to minimize mechanical malfunctions. The absence of guide pins, toggle levers, etc., also assists in the reduction of mechanical friction.

The double check valve assembly generally designated 33, shown in Figure 5, employs two duplicate check valve assemblies 10*a* and 10*b* which are substantially the same as the check valve 10 described in detail above. These check valve assemblies are arranged at right angles to each other and positioned at 45° to the axis of the inlet terminal 34 and the outlet terminal 35. The construction and operation of each of these check valve assemblies 10*a* and 10*b* is the same as that of the check valve assembly 10 described above. Moreover, the geometric relationship of the assemblies 10*a* and 10*b* as shown in Figure 5 produces a uniform flow, pattern by minimizing the extent of the changes in direction of flow and the extent of obstructions to forward flow, thus minimizing fluid pressure losses.

The chart of Figure 6 shows the pressure loss through the double check valve assembly of Figure 5, for both the nominal size of three-quarter inch and the nominal size of one inch. It will be observed that the pressure loss through the assemblies actually falls off as the flow rate increases, up to about 15 gallons per minute for the three-quarter inch size and up to about 18 gallons per minute for the one inch size.

It will be observed that the moving parts of each check valve assembly 10*a* and 10*b* may be installed and removed independently without any need to disconnect the entire assembly from the line. Moreover, each check valve assembly is so arranged as to utilize the full impact of the dynamic pressure in the supply line when in forward flow operation, for effectively minimizing hydraulic pressure losses. Furthermore, each check valve assembly is so arranged as to have portions of the poppet thereof protruding into its respective discharge passage, or in communication with its discharge passage, so as to be responsive to the slightest reverse flow action, closing rapidly to prevent backflow.

The backflow preventer asssembly shown in Figures 7, 8 and 9 includes a double check valve assembly 33 having its inlet terminal 34 connected to a supply pipe 36 through a shutoff valve 37 and a union coupling 38. The outlet terminal 35 of the double check valve assembly 33 is connected through union coupling 39 and shutoff valve 40 to the service pipe 41.

A control valve assembly 43 is connected to the double check valve assembly 33 by means of discharge pipe 44 and pressure-sensing lines 45 and 46. The discharge pipe 44 forms a portion of a stationary housing 47 which contains a removable valve seat 48. A valve stem 49 carries a valve head 50 at its lower end and a resilient disc 51 on the valve head closes against the seat 48. When the parts are in position as shown in Figure 9, the valve is closed and therefore discharge of fluid from the port 52 in the double check valve assembly 33 through discharge pipe 44

is prevented. The port 52 is located downstream from the check valve 10*a* and upstream from the check valve 10*b*.

Means are provided for moving the stem 49 to open or close the valve 48, 50, and as shown in the drawings this means includes a flexible diaphragm 54 having its outer periphery clamped between a flang 55 on the housing 47 and a flange 56 on a cover 57. The inner portion of the diaphragm 54 is clamped to the stem 49 between plates 58 and 59. A seal ring 60 on the stem 49 slides within a housing bore 61, and a seal ring 62 on an annular piston 63 of the stem 49 slides within the housing bore 64.

A chamber 65 is formed within the housing 47 below the diaphragm 54 and a chamber 66 is formed above the diaphragm within the cover 57. The chamber 65 communicates through passage 46 and port 67 with the inlet passage 68 of the check valve assembly 10*a*. The chamber 66 is connected through a cover port 69, passage 45 and a port 70 with an inlet passage 71 for the check valve assembly 10*b*. From this description it will be understood that the differential pressure acros the diaphragm 54 is the same as the differential pressure between the inlet passage 68 and the inlet passage 71.

A coil compression spring 73 in the chamber 66 acts on the diaphragm plate 58 to urge the stem 49 in a direction to open the discharge valve 48, 50. The force of the spring is assisted by the pressure in the chamber 66 and is opposed by the pressure in the chamber 65. This opposition force is increased by the fluid pressure acting against the underside of the annular piston 63. The annular space above the piston 63 and within the housing 47 is vented to atmosphere through vent port 74.

In operation, the differential control valve 43 serves to vent the zone between th check valve assemblies 10*a* and 10*b* through the discharge port 52 whenever the downstream pressure approaches the upstream pressure within a predetermind amount. Thus for example, the parts may be designed and adjusted so that when the pressure in the inlet terminal 34 is less than 2 psi greater than the pressure in the outlet terminal 35, the differential control valve 43 will open to permit fluid to flow from the zone port 52 through the pipe 44 and through the open valve 48, 50 to atmosphere. The several forces applied to the stem 49 in addition to gravity are the opposing forces developed by inlet pressure reflected in chamber 65, outlet pressure reflected in chamber 66, zone pressure at port 52 reflected against piston 63, as well as on discharge valve 50, and the force of spring 73.

It will be observed that the effective area of the diaphragm 54 is much greater than that of the valve seat 48. Also, the ports 67 and 70 are angularly positioned to reflect both static and dynamic pressures in their respective passages. Accordingly, the differential control valve 43 causes fluid to be vented out through zone port 52 whenever the outlet passage pressure from check valve assembly 10*a* (reflected through line 45) plus the force of the spring 76, plus the effect of gravity, exceeds the inlet passage from passage 68 (reflected through line 46) acting in chamber 65. The balance piston 63 has the same effective area as that of the seat 48, plus that of the communicating stem 49, so that the pressure exerted on the valve head 50 and the sliding stem 49 is balanced out by the pressure exerted on the piston 63. In similar fashion, the differential control valve 43 remains closed to prevent loss of fluid through the zone port 52 so long as the total force generated by inlet pressure in the chamber 65 exceeds the sum of the force generated by outlet pressure in chamber 66 supplemented by the force of the spring 73 and by the effect of gravity.

The chart of Figure 10 shows the pressure loss through the backflow preventer assembly shown in Figures 7 to 9, for both the nominal size of three-quarter inch and the nominal size of one inch, when normal flow occurs in the forward direction. It will be observed that the pressure loss through the entire backflow preventer assembly actually falls off as the flow rate increases up to about 20 gallons per minute for the one inch size.

In the modified form of differential control valve shown in Figures 11 and 12, an axial passage 75 in the stem 49*a* replaces the cover port 69. This passage 75 and its side outlet port 76 establishes communication between the cover chamber 66 and the discharge pipe 44. Only one sensing line 46 is used, and it connects the chamber 65 through line 46 to the inlet passage 68, as described above. The sensing line 45 and port 70 are not used. Figure 11 shows the parts of the differential control valve in closed position corresponding to normal forward flow operation, and Figure 12 shows the same parts in position to discharge fluid from the zone port 52 to atmosphere when backflow conditions are present or imminent. In other respects, the construction and operation of the modified form of the differential control valve shown in Figures 11 and 12 are the same as those previously described.

Thus it may be seen that the invention, at least in its preferred embodiments, provides a check valve suitable for use in backflow prevention apparatus and which is constructed to provide a relatively high initial resistance to flow and yet as the flow increases provides a reduced pressure drop across the valve.

The invention also provides a pair of series-connected check valves in combination

with a differential control valve for venting the zone between the check valves when the downstream pressure approaches the upstream pressure within a predetermined amount.

WHAT WE CLAIM IS:—

1. A check valve comprising an inlet passage terminating in an annular valve seat, a barrel coaxial with the valve seat and of larger diameter than the valve seat, a valve poppet having a flange slidably guided within the barrel and being axially movable towards and away from said valve seat, a spring arranged to urge the poppet towards sealing contact with the valve seat, a chamber bounded in part by the poppet remote from the valve seat, and an outlet passage, wherein a portion of said flange projects into the outlet passage to define a region in the fluid flow path in which the velocity of flowing fluid in use is greater than in the rest of the outlet passage and the pressure is correspondingly less and wherein the chamber communicates with said region whereby increasing flow of fluid through the check valve from the inlet passage to the outlet passage in use causes a reduction in pressure in the chamber to oppose the action of the spring.

2. A check valve as claimed in claim 1 in which the spring comprises a coil compression spring mounted within said chamber.

3. A check valve as claimed in claim 1 or 2 wherein said poppet has two axially spaced flanges slidably guided within said barrel and defining an annular groove between the flanges, the groove communicating with said region, and at least one passage communicating the groove with the chamber.

4. A check valve as claimed in any preceding claim in which the inlet passage is provided with an inlet terminal and the outlet passage is provided with an outlet terminal.

5. A check valve as claimed in claim 4 in which said terminals are axially aligned.

6. A check valve as claimed in claim 5 in which the axis of movement of said valve poppet is perpendicular to the axis of said terminals.

7. A check valve as claimed in claim 5 in which the axis of movement of said valve poppet is disposed at an angle of about 45° with respect to the axis of said terminals.

8. A check valve as claimed in claim 5 in which the axis of movement of said valve poppet is the same as the axis of said terminals.

9. A check valve as claimed in claim 4 in which the axes of said terminals are disposed at right angles, and wherein the axis of movement of said valve poppet is the same as the axis of said inlet terminal.

10. A check valve substantially as hereinbefore described with reference to any of Figures 1 to 4 of the accompanying drawings.

11. A check valve assembly comprising a check valve as claimed in any preceding claim connected in series with another check valve as claimed in any preceding claim, the outlet passage of one check valve forming the inlet passage of the other check valve.

12. A check valve assembly as claimed in claim 11 in which the inlet passage of one check valve is provided with an inlet terminal and the outlet passage of the other check valve is provided with an outlet terminal, said terminals being axially aligned, and the axes of movement of the valve poppets being disposed substantially at 45° with respect to the axis of said terminals and being substantially perpendicular to each other.

13. A check valve assembly substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings.

14. A backflow preventer assembly comprising two check valves as claimed in any of claims 1 to 10 connected in series and defining a zone between them, and means including a control valve actuable to vent said zone to atmosphere, said control valve having means responsive to differential pressure across the upstream check valve for actuating said control valve.

15. An assembly as claimed in claim 14 including a first port arranged for sensing both static and dynamic heads in the inlet passage of the upstream check valve, and also including a second port arranged for sensing the pressure in the outlet passage of the same check valve.

16. An assembly as claimed in claim 15 wherein the second port is arranged for sensing both static and dynamic heads in the outlet passage of the upstream check valve.

17. An assembly as claimed in claim 15 or 16 wherein said control valve comprises a housing provided with a valve seat, a stem mounted to move axially in the housing and having a valve head movable to close against said seat, a cover, a flexible diaphragm having its periphery clamped between th cover and the housing and acting to define a chamber in the housing and a chamber in the cover, means connecting the central portion of the diaphragm to the stem, a spring in the cover chamber urging the stem in a direction to open the valve, a discharge pipe connecting the zone to said housing, a first pressure sensing line communicating the first port with the housing chamber and a second pressure sensing line communicating the second port with the cover chamber, and a balance piston fixed on the stem slidably mounted within the housing to balance the fluid pressure force from the discharge pipe tending to move the valve head away from the valve seat.

18. An assembly as claimed in claim 17 wherein said second pressure sensing line comprises a passage in the stem communicating the cover chamber with the interior of the housing.

19. A backflow preventer assembly substantially as hereinbefore described with reference to any of Figures 7 to 12 of the accompanying drawings.

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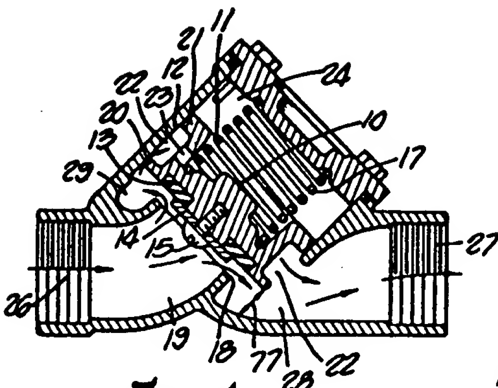


FIG. 1.

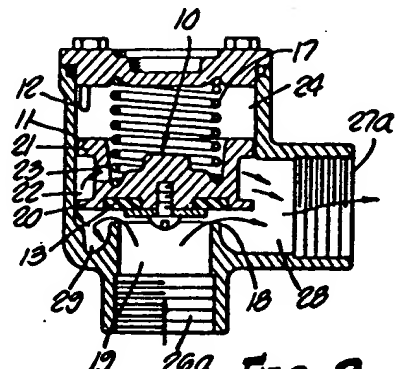
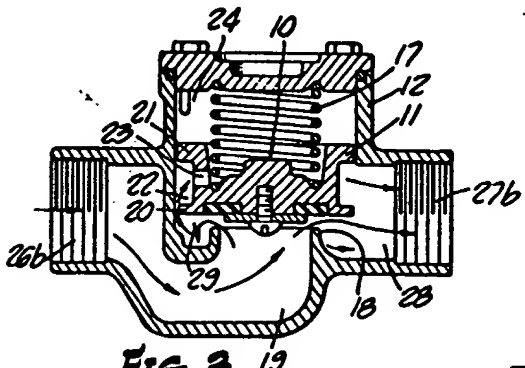


FIG. 2.



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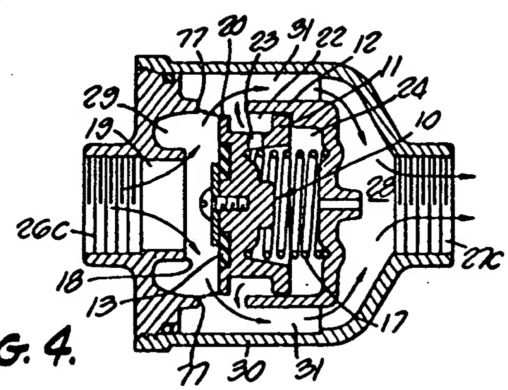
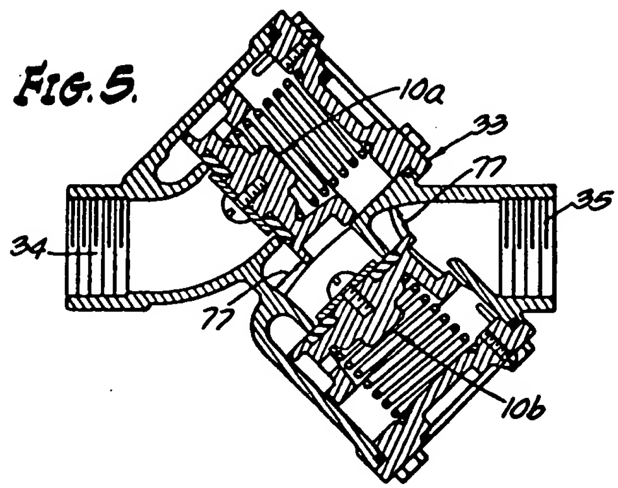


FIG. 4.

FIG. 5.



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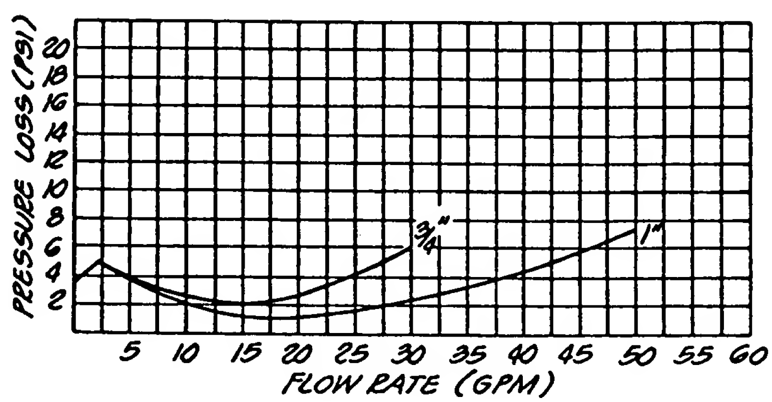
10b



PRESSURE LOSS (PSI)
20
18
16
14
12
10
8
6
4
2
3/4"
1"
5 10 15 20 25 30 35 40 45 50 55 60
FLOW RATE (GPM)

FIG. 6.

1490553 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

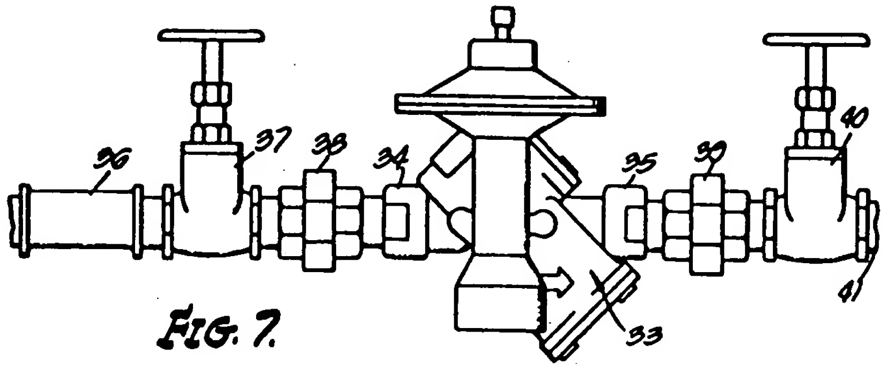
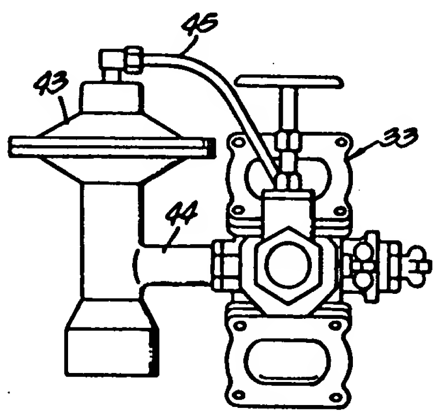


FIG. 7.



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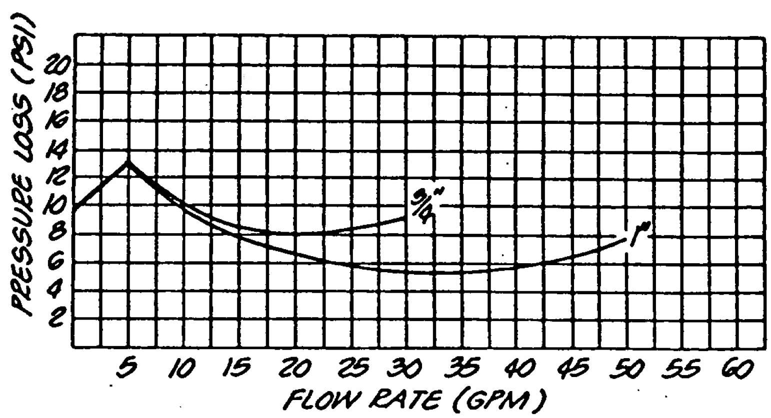

FIG. 10.

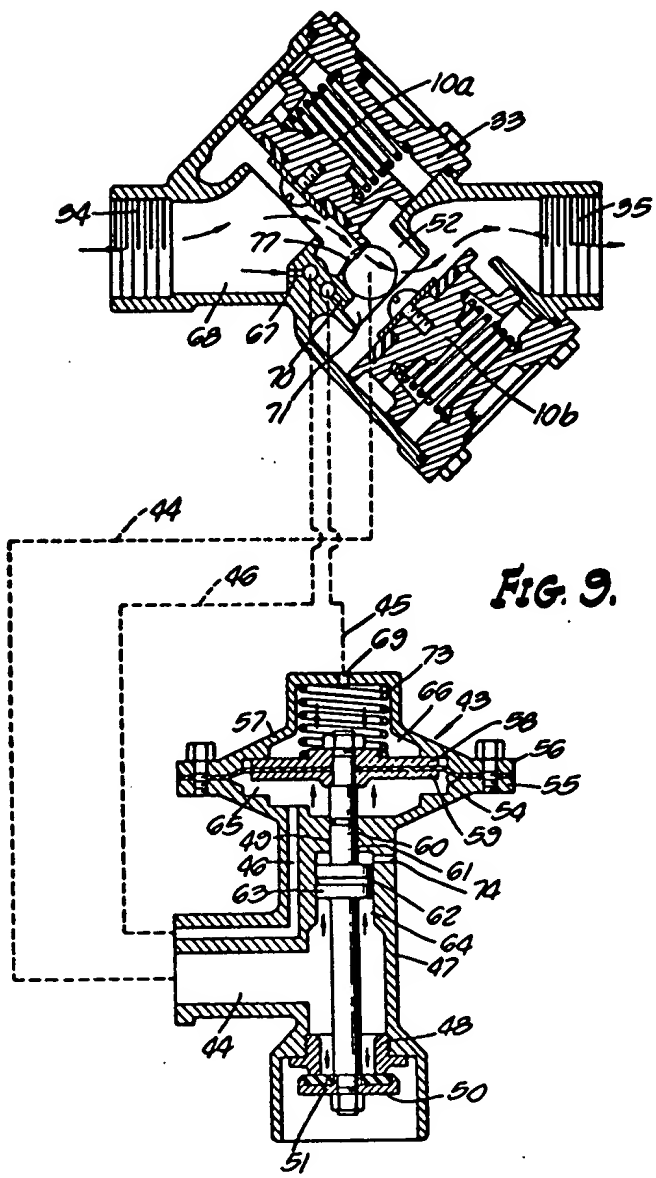
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FIG. 9.

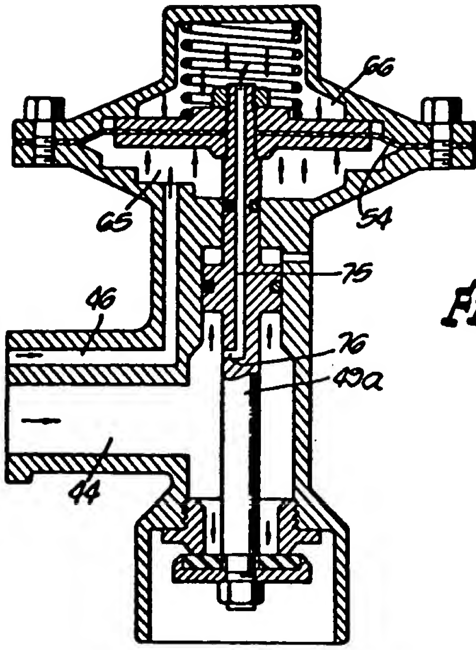

FIG. 11.

FIG. 12.